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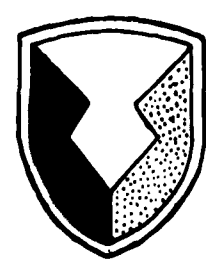
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COATING and CHEMICAL LABORATORY



CCL REPORT NO. 137

INFLUENCE OF THE HLB OF A NONIONIC ADDITIVE ON THE
DETERGENCY OF ALKALINE CLEANERS CONTAINING AN ANIONIC SURFACTANT

BY

A. MANKOWICH

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ABSTRACT

The resultant of the combined properties of penetrability, peptization, and wetting, as judged by asphalt detergency, shows synergism on the addition of certain nonionics to medium pH alkaline cleaning solutions (capH12) containing an anionic surfactant. Nonionic additives with HLB values of 13.2 to 17.1 imparted good to excellent asphalt detergency to solutions containing sodium dodecyl sulphate (SDS) or alkyl (straight chain) aryl sulphonate (SKBS); and nonionics with HLB values of 13.4 to 18.18 gave fair to excellent asphalt removal in cleaners containing sodium oleate. In all three systems, asphalt detergency decreased with further increase in nonionic HLB to 19.05. The anionic with the highest HLB (SDS) formed the most synergistic mixtures in the 13.2 to 17.1 nonionic HLB range. The order of increasing synergism displayed by the anionic surfactants (sodium oleate, SKBS, SDS) with nonionics of 17.1 HLB maximum is that of increasing surface tension of the respective anionics (pure). Increasing HLB of the nonionic additives correlates in general with increasing surface tension of their 0.39% solutions (their concentrations in the cleaning solutions investigated); and the effectiveness of the nonionics in improving asphalt detergency increases with increasing values of nonionic surface tension until a nonionic HLB of 17.1 is reached. The order of increasing synergism in the nonionic HLB range of 13.4 to 17.1 is also that of increasing critical micelle concentration of the pure anionic surfactants. It is indicated that this order is also that of increasing anionic CMC (critical micelle concentration) lowering.

A number of synergistic anionic-nonionic surfactant combinations were developed suitable for use in cleaners of the Federal Specification P-C-436a type. These combinations could meet detergency plus surface tension, or detergency, requirements of the specification.

I. INTRODUCTION

The usual theories of detergency postulate that the mechanism consists, in whole or part, of preferential adsorption of surfactant by the basis material, lowering of the boundary surface free energy, emulsification, capillary penetration and peptization, and micellar solubilization. An alternative process has recently been proposed (1) which suggests that detergency is due to the cryoscopic forces originating in the van der Waal attractions between the hydrocarbon chains of fatty soil and surfactant. This theory states that in a surfactant/water/soil system soil is penetrated even at room temperature by aqueous surfactant solution with the formation of a liquid-crystalline phase from the close-packed soil and surfactant hydrocarbon chains. Some investigators (2), believing there is a connection between detergency and the liquid-crystalline phase containing soil, have further suggested that deter-sive efficiency depends on the presence of liquid crystals (anisotropy) in the aqueous cleaning solution. This hypothesis goes on to say that, since anisotropy is due to close-packed lamellar micelles, good detergency should result from combinations of anionic and specific nonionic surfactants which tend to form such aggregates. The latter are mixed micelles in which hydrocarbon chains of the nonionic molecules have penetrated between those of the anionic molecules of the outer micellar layers, with the hydrophilic groups of the former lying in the ionic portion of the outer layer (3). Recent studies indicate that improved detergency and foam stability result from increasing hydrophilicity of the polar portion of the nonionic surfactant (4). There is also support for the belief that nonionic additives containing highly hydrophilic polar groups are to be avoided because they tend to form isotropic solutions (2).

The hydrophilicity of the polar part of a nonionic compound is related to the hydrophile-lipophile balance, HLB, of the latter. The preceding views, therefore, can be reduced to the question as to whether high (4), or low (2), HLB nonionic additives to anionic syndets tend to improve detergency.

This investigation is an attempt to resolve this question. But caution must be exercised in the approach. Work at this laboratory has indicated that surfactant HLB is only one of several parameters determining soil removal efficiency (5). Detergency is such a complex process that it would be an oversimplification to expect correlation with one factor only. It must be noted that the proponents of the view that low HLB nonionic additives favor improved detergency (2) found important exceptions. These differences were attributed to very strong ion-dipole interaction (sulphonate ion from the anionic and hydroxyl groups of the nonionic) reducing the attraction of the ion-dipole for water, regardless of the high HLB of the nonionic.

II. DETAILS OF TEST

A. Experimental

Detergency was determined essentially as described in Federal Specification P-C-436a, by techniques that simulate practical soak tank cleaning thru the use of relatively large volumes of boiling detergent solution. Because of the extensive program, the steel test panels, after standardized polishing and prior to soil application and aging, were cleaned in c.p. acetone instead of in alkaline detergent. Non-detergent, SAE 30 mineral oil and

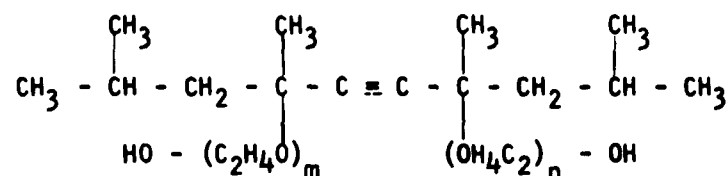
petroleum asphalt were used as soils.

Cleanliness of panels soiled with mineral oil was evaluated by the "residue-pattern" method (6), which carries the sensitive water break procedure thru a supplementary confirmatory step. Satisfactory ("good") mineral oil detergency in this investigation, therefore, implies the production of a "chemically-clean" surface. Asphalt detergency was evaluated by the gravimetric method.

Surface tensions were determined by a du Nouy tensiometer at 25 - 26°C with test solutions aged one hour. Harkins-Jordan correction factors were applied.

B. Surfactants

Three types of anionic detergents were studied; viz; sodium dodecyl sulphate (USP), commercial sodium keryl (C₁₀ - C₂₀ straight chain alkyl) benzene sulphonate (40% active), and sodium oleate soap (purified grade). The nonionic additives, commercial products, included homologous series of ethylene oxide condensates of nonyl phenol and of 2, 4, 7, 9-tetramethyl-5-decyne-4, 7-diol. An ethylene oxide adduct (9 - 10 mole ratio) of t-octylphenol was also studied. The structure of the decynediol derivatives is exemplified by the following 15 mole adduct:



where, (m + n) = 15

The HLB values of the nonionic surfactants were computed by Griffin's method for polyethenoxy adducts (7), and the values for the anionic detergents were taken from the literature (7). The symbols of the surfactants and their HLB numbers are:

Ethylene oxide adducts of nonyl phenol

15 mole ratio adduct	----	NPPGE	----	15.00	HLB
30 mole ratio adduct	----	NPTGE	----	17.20	HLB
50 mole ratio adduct	----	NP50E	----	18.18	HLB
100 mole ratio adduct	----	NP100E	----	19.05	HLB

Ethylene oxide adducts of the decyne - 4, 7 - diol

10 mole ratio adduct	----	D-10	----	13.21	HLB
15 mole ratio adduct	----	D-15	----	14.90	HLB
30 mole ratio adduct	----	D-30	----	17.08	HLB

Polyoxyethylene - (9 - 10) - of t-octylphenol

	OPE9 - 10	----	13.40	HLB
Sodium dodecyl sulphate	-----	SDS	-----	40.0 HLB
Sodium keryl benzene sulphonate	-	SKBS	-----	11.7 HLB
Sodium oleate	-----	sodium oleate	--	18.0 HLB

C. Detergent Solution Composition and Standards of Detergent Efficiency

The soil removal - HLB studies were performed in 7.5% solutions containing the amounts of builders prescribed for the Federal Specification P-C-436a standard comparison compound (S.C.C.), as follows:

Sodium metasilicate pentahydrate	-----	34.5%
Primary sodium phosphate monohydrate	-----	12.0%
Trisodium phosphate dodecahydrate	-----	33.5%
OPE9 - 10	-----	5.2%
SKSB	-----	14.8%

In every case, 20% of the formulation, as above, consisted of surfactants or surfactants plus neutral builder, sodium sulphate. Thus, the tests were made in practical detergent solutions of ca pH12 (P-C-436a requirement is 12.1 maximum for 7.5% solution at 25°C), suitable for use on both ferrous and non-ferrous materials.

The medium pH, soak tank cleaners of the P-C-436a type have been found to exceed the conventional, heavy duty (high alkalinity) alkaline cleaners in deterative ability because of the synergism of their surfactant combination. It has been postulated (8) that a cleaner capable of passing the P-C-436a mineral oil and asphalt cleaning tests possesses "improved detergency", above that of the conventional cleaners. The latter can deterge mineral oil, but cannot remove the sticky, strongly adherent asphalt, possibly because of deficiencies in one or more of the surface-active characteristics of wetting power, penetrability, and peptizing power. The practical significance of the asphalt test is, of course, that it provides a rapid and simple indication of the afore-mentioned properties.

III. RESULTS AND DISCUSSION

A. Detergency vs HLB in Built Cleaners Containing Anionic-Nonionic Mixtures

Tables I and II show the effect of the HLB of the nonionic additive on the detergency of built alkaline cleaners (those with anionic-nonionic mixtures contain 11.1% total active material, dry basis). The cleaners are formulated with one of the three chief types of anionic syndets, the HLB values of which vary considerably (11.7 to 40.0), thus also showing the effect of anionic HLB level.

The data indicated that conventional alkaline cleaners (containing only one syndet, anionic or nonionic) in solutions of ca pH12 can deterge SAE 30 mineral oil (sodium oleate soap was an exception). Cleaner 56 containing the 10 mole ratio ethylene oxide adduct of decynediol, D-10, was borderline in

this respect. It is to be noted that the additive D-10 has the lowest HLB of the nonionics tested, and that none of the cleaners containing only one surfactant could remove asphalt soil.

Nonionic surfactants with HLB values of 13.2 to 17.1 imparted excellent asphalt detergency to solutions containing sodium dodecyl sulphate, SDS (5 - 9 minute cleaning) and imparted good asphalt detergency to solutions with the alkyl aryl sulphonate, SKBS (9 - 12 minute cleaning). For both SDS and SKBS systems (containing nonionic additives), there was no significant variation of asphalt detergency with increase of nonionic HLB in this range. In cleaning solutions containing sodium oleate soap as the anionic surfactant, asphalt detergency improved from passably fair (21 minute cleaning) with a 13.4 HLB nonionic additive to excellent (7 - 10 minute cleaning) in the 15.0 - 18.18 nonionic HLB range. With all three systems, asphalt detergency then fell off sharply with further increase in nonionic HLB value to 19.05. The data further indicated that the anionic with the highest HLB, sodium dodecyl sulphate (40.0 HLB), formed the most synergistic detergent mixtures with nonionic additives in the 13.2 to 17.1 HLB range. It must be noted that the 17.1 nonionic HLB point seems to be a characteristic one for systems containing sulphonate or sulphate anionics, a point beyond which further increase in the HLB of the nonionic additive caused a decrease in surface-active properties as judged by asphalt detergency. Of interest is the fact that mineral oil detergency was good thruout the nonionic HLB range of 13.2 to 19.05 for the sodium dodecyl sulphate mixtures; while for the soap and alkyl aryl sulphonate systems, it was good only in the nonionic HLB range of 13.4 to 17.2. Table I shows no general correlation between asphalt detergency and either nonionic mole fraction in the surfactant mixture or net HLB of the latter.

Table III shows principally that good asphalt detergency could be imparted to cleaners containing a very low percentage (1.6% active material) of the alkyl aryl sulphonate, SKBS, by a wide concentration range of the D-30 nonionic (1.0 - 5.2%). The upper limit is an economic cut-off point. Within the family of ethylene oxide adducts of decynediol, direct correlation existed between increasing asphalt detergency and nonionic HLB in the 13.2 - 17.1 range, for cleaners containing the SKBS anionic. Because of the increasing molecular size of the decynediol adducts in this HLB range, there was also direct correlation between increasing asphalt detergency and decreasing nonionic mole fraction in the surfactant mixture. However, there was no correlation between asphalt detergency and the nonionic mole fraction of the NPTGE-SDS surfactant mixture, in which the change in mole fraction was accomplished by varying the amount of NPTGE nonionic in the cleaner. Detergency was fair to good in cleaners containing the NPTGE-SDS combination.

B. Surface Tension, Asphalt Detergency, and HLB

Table IV shows that in the built alkaline cleaners described herein (Table I) anionic syndets vary in the synergism (magnified surface-active abilities as revealed by asphalt detergency power) they produce when combined with nonionic agents. With nonionics of 17.1 HLB maximum, the order of increasing synergism is sodium oleate, SKBS, and SDS, while for nonionics of greater HLB (to 19.05), this order is reversed. It is important to note that the order of soap, straight chain alkyl aryl sulphonate, and primary alkyl sulphate is that of increasing surface tension of the pure anionic syndets.

Table V reveals, first, that increasing HLB of the nonionic additives correlates in general with increasing surface tension of their 0.39% solutions (their concentrations in the Table I cleaners), and, second, the effectiveness of nonionic surfactants in improving asphalt detergency increases with increasing values of nonionic solution surface tension until a nonionic HLB of 17.1 is reached, with further increase of nonionic surface tension reversing this trend.

C. Critical Micelle Concentration and HLB

It is significant that the order of increasing synergism of surface-active properties of cleaners containing anionic-nonionic mixtures is also that of increasing critical micelle concentration (CMC) of the pure anionic surfactants; viz;

Anionic	CMC (molar)	Reference
sodium oleate	.0007	(3)
SKBS*	.0015	(11)
SDS	.0081	(12)

*for a 12 carbon straight chain alkyl benzene sodium sulphonate

This means that the higher the anionic CMC, the greater the asphalt detergency imparted to the cleaner by a nonionic additive in the 13.4 - 17.1 HLB range. Harkins (3) related the lowering of anionic CMC by nonionic additives to the formation of mixed micelles thru polar-nonpolar solubilization, in which the hydrocarbon chains of the nonionics penetrate between those of the anionic molecules in the outer micellar layers with the hydrophilic groups of the nonionic lying in the ionic portions of the outer layers. The amount of such CMC lowering has been connected with improved foam stability of alkaline detergent solutions containing anionic-nonionic mixtures(10). Nonionic surfactants in general possess low CMC values; for example, the CMC of NPTGE is 0.000275 molar (13). Since the CMC of an anionic-nonionic mixture lies between the values of the individual surfactants (14), it appears that the greatest CMC lowering by a nonionic additive would be effected in the case of the anionic having the largest CMC. It is to be noted that such is the case herein, and that it is probable that the increasing order of superiority of the anionics (soaps, straight chain alkyl benzene sulphonate, and primary alkyl sulphate) is also the order of increasing anionic CMC lowering (for cleaners with nonionics in the 13.4 - 17.1 HLB range).

It is suggested that the drop in asphalt detergency (that is, in surface-active characteristics) (a) in cleaners containing sulphonate or sulphate anionics when the nonionic HLB exceeds 17.1, and (b) in cleaners containing sodium oleate soap when the nonionic HLB is greater than 18.18 is due to the following sequence of events:

The increased hydrophilicity of the nonionic additive (resulting from the longer ethylene oxide chains) causes a change, or partial change, in the type of its solubilization by the anionic syndet, perhaps from oriented polar-nonpolar to adsorption solubilization in which there is no penetration of the anionic micelle by the nonionic; this change in type of

micellar interaction could influence the size, shape and charge density of the mixed micelle, with consequent effect on the combination of surface-active properties of capillar penetration, peptization, and wetting as indicated by asphalt detergency.

D. Developed Cleaners Meeting the Detergency and Detergency Plus Surface Tension Requirements of Federal Specification P-C-436a

A practical by-product of this study of the influence of the HLB of the nonionic additive on the deterative power of medium pH (12.1 maximum) alkaline cleaners containing an anionic syndet was the development of several cleaners meeting both the detergency and surface tension requirements of P-C-436a, and of a larger number meeting the detergency requirements only. Table II shows these cleaners. Specification P-C-436a refers only to the synergistic anionic-nonionic combination of SKBS plus OPE9-10. Equally good deterative and boundary tension depressant combinations are now revealed as sodium oleate plus OPE9-10, SDS plus OPE9-10, and sodium oleate plus NPPGE. The anionic-nonionic mixtures possessing detergent efficiency, but the tensions of which are higher than permitted by P-C-436a, are also of importance to formulators. The surface tension requirement of the specification is only a means of ensuring a suitable surfactant reserve when using a cleaner containing the SKBS plus OPE9-10 mixture. Hence, the following combinations are of significance as replacements or substitutes for the original synergistic combination: SKBS plus D-30, SKBS plus NPTGE, sodium oleate plus D-30, sodium oleate plus NPTGE, SDS plus all the decynediol adducts, and SDS plus NPTGE, and SDS plus NP100E.

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APPENDIX

TABLE I - DETERGENT SOLUTIONS* AND HLB CHARACTERISTICS

Cleaner**	Nonionic		Anionic		Surfactant Mixture	
	Weight %	HLB	Weight %	HLB	Net HLB	Mol-% Nonionic
23 - SCC	5.2% OPE9-10	13.40	14.8% SKBS	11.70	12.50	36.3
1	5.2% D-30	17.08	14.8% SKBS	11.70	14.22	18.7
40	5.2% NPTGE	17.20	14.8% SKBS	11.70	14.28	18.8
37	5.2% NP100E	19.05	14.8% SKBS	11.70	15.14	7.2
32	5.2% OPE9-10	13.40	5.9% sodium oleate	18.0	15.80	30.1
33	5.2% NPPGE	15.00	5.9% sodium oleate	18.0	16.60	23.4
31	5.2% D-30	17.08	5.9% sodium oleate	18.0	17.57	14.8
34	5.2% NPTGE	17.20	5.9% sodium oleate	18.0	17.63	14.8
38	5.2% NP50E	18.18	5.9% sodium oleate	18.0	18.09	10.0
35	5.2% NP100E	19.05	5.9% sodium oleate	18.0	18.49	5.5
24	5.2% OPE9-10	13.40	5.9% SDS	40.0	27.54	28.9
28	5.2% D-10	13.21	5.9% SDS	40.0	27.45	27.6
30	5.2% D-15	14.90	5.9% SDS	40.0	28.24	22.3
21	5.2% D-30	17.08	5.9% SDS	40.0	29.26	14.1
39	5.2% NPTGE	17.20	5.9% SDS	40.0	29.32	14.2
36	5.2% NP100E	19.05	5.9% SDS	40.0	30.19	5.2
2-A	5.2% NP100E	19.05	None		19.05	100
54	5.2% NP50E	18.18	None		18.18	100
2	5.2% D-30	17.08	None		17.08	100
57	5.2% OPE9-10	13.40	None		13.40	100
56	5.2% D-10	13.21	None		13.21	100
51	None		14.8% SKBS	11.70	11.70	None
53	None		5.9% sodium oleate	18.0	18.0	None
52	None		5.9% SDS	40.0	40.0	None

NOTES: * Containing the builders and adjuncts of the P-C-436a SCC (section 11-C).

** Concentration of all solutions = 7.5%

All cleaners contain 11.1% total active surfactant content, dry basis, except those with only one surfactant and all contain Na_2SO_4 equal to difference between 20% and % total surfactants.

14.8% SKBS contains (5.9% active material + 8.9% Na_2SO_4)

TABLE 11 - DETERGENT EFFICIENCY AND SURFACE TENSION OF TABLE 1 CLEANERS

Detergency		Cleaner**	Surface Tension +
Mineral Oil	Asphalt (minutes for removal)		
Good	12	23 - SCC	30.1
Good	9 - 9	1	40.1
Good	16	40	36.5
Unsatisfactory	21	37	40.3
Good	21	32	32.0
	13 - 10	33	35.6
	10 - 10	31	41.1
Good	9 - 7	34	38.6
Unsatisfactory	10	38	39.5
Unsatisfactory	18 - 15	35	40.1
	8	24	31.5
Good	5 - 6	28	41.5
	9 - 7	30	41.8
Good	7 - 6	21	42.2
Good	19	39	38.9
Good	21	36	41.4
Good	Poor	2 - A	
Good	Poor	54	
Good	Poor	2	
Good	Poor	57	
Poor rinsability	Poor	56	
Good	Poor	51	
Unsatisfactory	Poor	53	
Good	Poor	52	

+ Surface tension, dynes per cm, at 25 - 26°C, of 0.05% solutions aged 1 hour.

TABLE III - NONIONIC CONCENTRATION, HLB, AND DETERGENCY

Cleaner	% Active Content in Cleaner	Nonionic		Anionic		Surfact Mixture		Asphalt Detergency minutes for removal
		Weight %	HLB	Weight %	HLB	Net HLB	nonionic mole fraction	
27	7.3	5.2% D-10	13.21	5.2% SKBS	11.70	12.78	0.60	*31 mg residue
29	7.3	5.2% D-15	14.90	5.2% SKBS	11.70	13.99	0.53	14 - 17 - 21
3	7.3	5.2% D-30	17.08	5.2% SKBS	11.70	15.54	0.40	10 - 10
1	11.7	5.2% D-30	17.08	14.8% SKBS	11.70	14.22	0.19	9 - 9
4	6.8	5.2% D-30	17.08	3.9% SKBS	11.70	15.84	0.47	18 - 18
5	6.2	5.2% D-30	17.08	2.6% SKBS	11.70	16.18	0.57	*30 mg residue
6	4.2	2.6% D-30	17.08	3.9% SKBS	11.70	15.06	0.30	12 - 12
7	3.2	1.6% D-30	17.08	3.9% SKBS	11.70	14.42	0.21	12 - 12
8	2.6	1.0% D-30	17.08	3.9% SKBS	11.70	13.80	0.14	15 - 15
9	2.1	0.5% D-30	17.08	3.9% SKBS	11.70	13.01	0.08	*2 mg residue
10	2.6	0.5% D-30	17.08	5.2% SKBS	11.70	12.74	0.06	21 - 18
42	8.5	2.6% NPTGE	17.2	5.9% SDS	40.0	29.32	0.08	11 - 11
39	11.1	5.2% NPTGE	17.2	5.9% SDS	40.0	29.32	0.14	19
41	20.0	14.1% NPTGE	17.2	5.9% SDS	40.0	29.32	0.31	13 - 12

NOTES: * Asphalt residues after 21 minutes cleaning.

** All cleaners contain the builders and adjuncts of the P-C-426a SCC, and also Na_2SO_4 equalling the difference between 20% and % total surfactants.

All solution concentrations = 7.5%

TABLE IV - ANIONIC SURFACE TENSION VS ASPHALT DETERGENCY*

Anionic	Anionic surface tension, dynes/cm. at 25°C.	Nonionic agent and asphalt detergency (minutes for removal)			
		OPE9 - 10 (HLB = 13.4)	D - 30 (HLB = 17.08)	NPTGE (HLB = 17.20)	NP100E (HLB = 19.05)
Sodium oleate	27.0	21	10 - 10	9 - 7	18 - 15
SKBS	30.5	12	9 - 9	16	21
SDS	37.8	8	7 - 6	19	21

NOTES: * For cleaners containing the listed anionic-nonionic mixtures (Tables I and II).

** Surface tension of pure anionic agents at concentration 0.44 grams per 100 ml (Table I concentrations):

Sodium oleate ----- reference 9
 SKBS ----- reference 10
 SDS ----- reference 9

TABLE V - SURFACE TENSIONS OF 0.39% SOLUTIONS OF VARIOUS NONIONIC AGENTS*

Nonionic	Surface tension, dynes per cm	Temperature °C	HLB
OPE9 - 10	30.0	25.8	13.40
D - 10	30.5	25.8	13.21
NPPGE	35.3	25.6	15.00
D - 15	33.6	25.3	14.90
D - 30	36.1	25.4	17.08
NPTGE	42.4	25.6	17.20
NP50E	45.1	25.5	18.18
NP100E	45.0	25.8	19.05

NOTE: * Concentration of the nonionic additives in the 7.5% of cleaning solutions of Table I, all formulations of which contain 5.2% nonionic by weight, dry basis.

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<p>AD No _____ Accession No _____</p> <p>Coating & Chemical Laboratory, Aberdeen Proving Ground, Md., CCL # 137 - INFLUENCE OF THE HLB OF A NONIONIC ADDITIVE ON THE DETERGENCY OF ALKALINE CLEANERS CONTAINING AN ANIONIC SURFACTANT</p> <p>A. Mankowich, Rpt No. 137, 10 January 1963, 16 pgs, AMCMS Code 5026.11.84205, DA Proj No 593-32-007</p> <p>The resultant of the combined properties of penetrability, peptization, and wetting, as judged by asphalt detergency, shows synergism on the addition of certain nonionics to medium pH alkaline cleaning solutions (capH12) containing an anionic surfactant. Nonionic</p>	Unclassified	Unclassified	<p>AD No _____ Accession No _____</p> <p>Coating & Chemical Laboratory, Aberdeen Proving Ground, Md., CCL # 137 - INFLUENCE OF THE HLB OF A NONIONIC ADDITIVE ON THE DETERGENCY OF ALKALINE CLEANERS CONTAINING AN ANIONIC SURFACTANT</p> <p>A. Mankowich, Rpt No. 137, 10 January 1963, 16 pgs, AMCMS Code 5026.11.84205, DA Proj No 593-32-007</p> <p>The resultant of the combined properties of penetrability, peptization, and wetting, as judged by asphalt detergency, shows synergism on the addition of certain nonionics to medium pH alkaline cleaning solutions (capH12) containing an anionic surfactant. Nonionic</p>
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